Navigation Channel Design Using Real-Time Marine Simulation

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ERDC

Bringing the real world into a laboratory environment.

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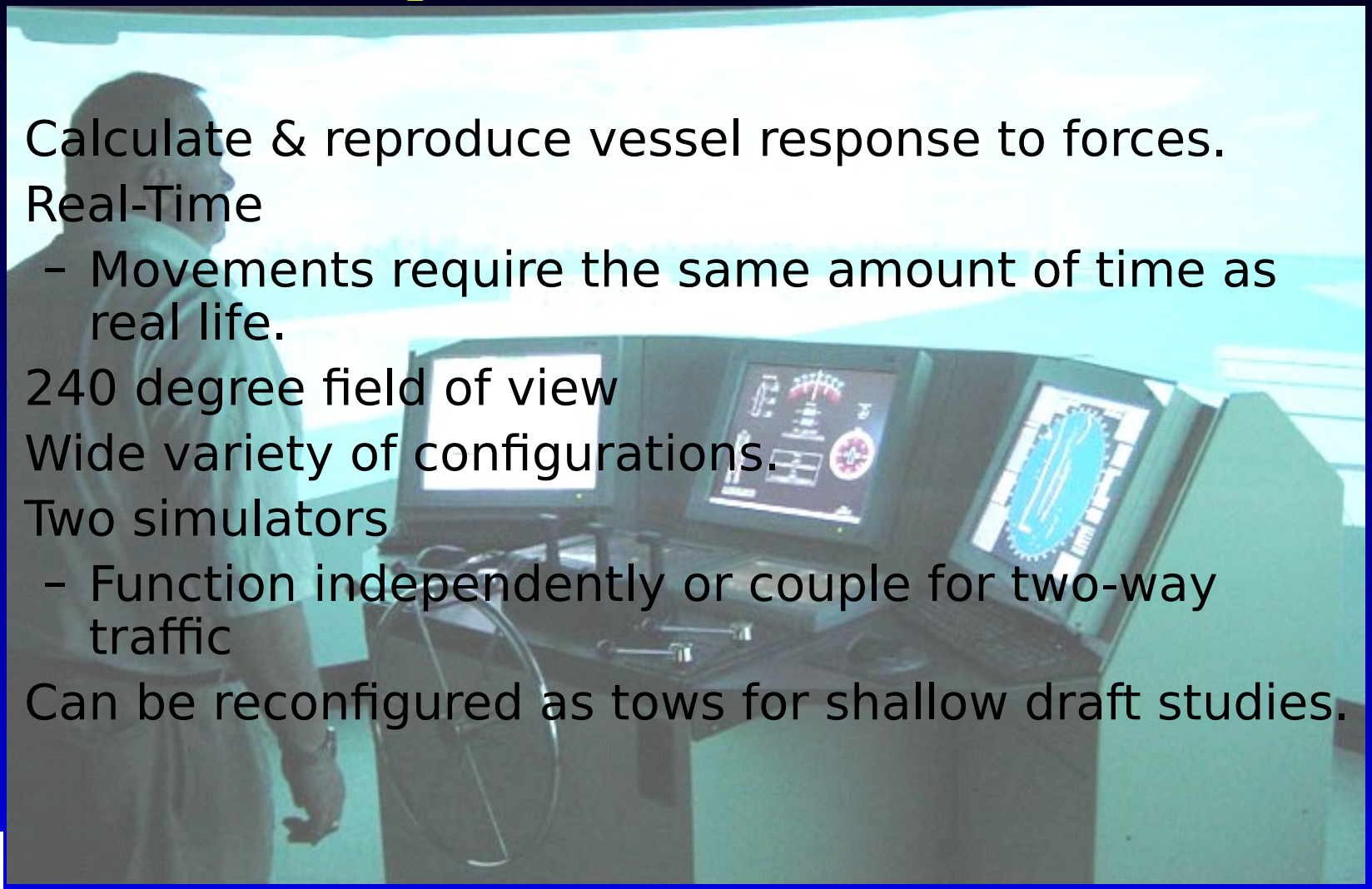
Why do we model navigation projects?

- Allows end-users a controlled environment to operate ships in their waterway of the future.
  - Safety check
  - Gets pilots “onboard” project.
- Allows comparison between multiple proposals.
- Allows optimization of channel dimensions.
- Provides rationalization of project design to competing interests.
- Because it’s the law.

ER 1110-2-1403

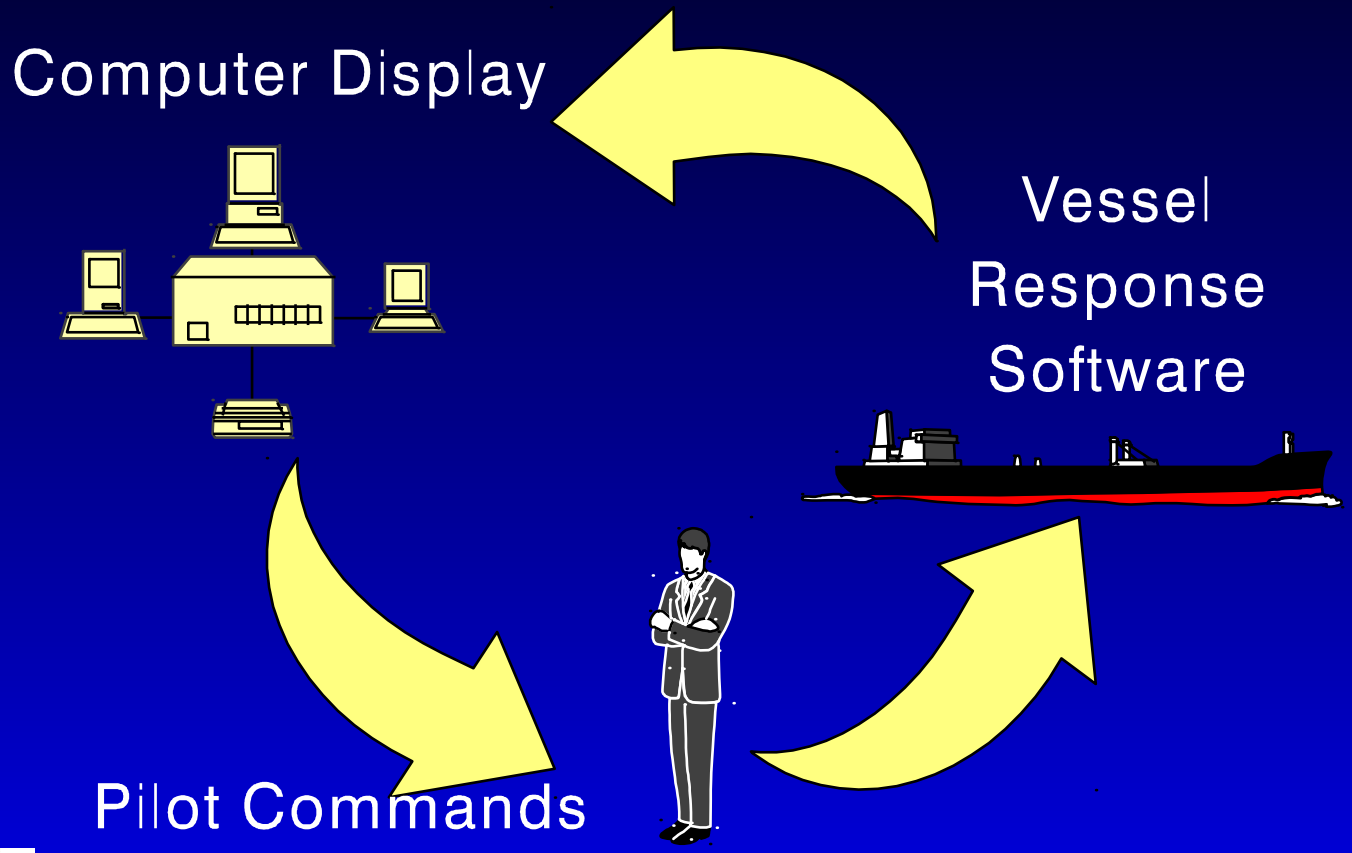
- Engineering and Design: Studies by Corps Hydraulic and Hydrologic Facilities and Others.
  - Paragraph 6b. *Hydraulic design studies associated with the planning, design, construction, operation, and maintenance of of navigation channels will include a ship-simulation investigation unless omission of such an investigation is approved by HQUSACE. This policy does not pertain to the design of commercial small-craft harbor channels.*

ERDC Ship/Tow Simulators



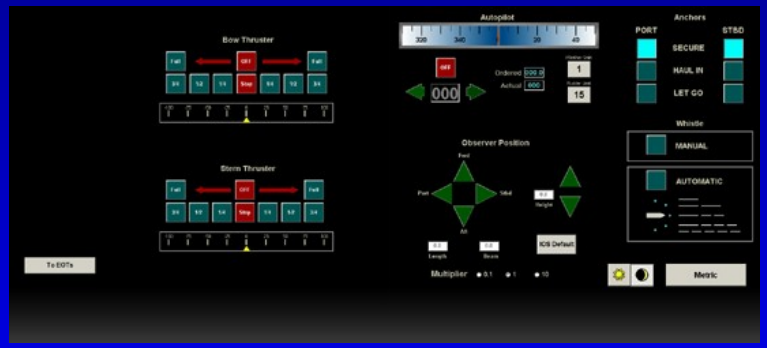
- Calculate & reproduce vessel response to forces.
- Real-Time
  - Movements require the same amount of time as real life.
- 240 degree field of view
- Wide variety of configurations.
- Two simulators
  - Function independently or couple for two-way traffic
- Can be reconfigured as tows for shallow draft studies.

Man In The Loop



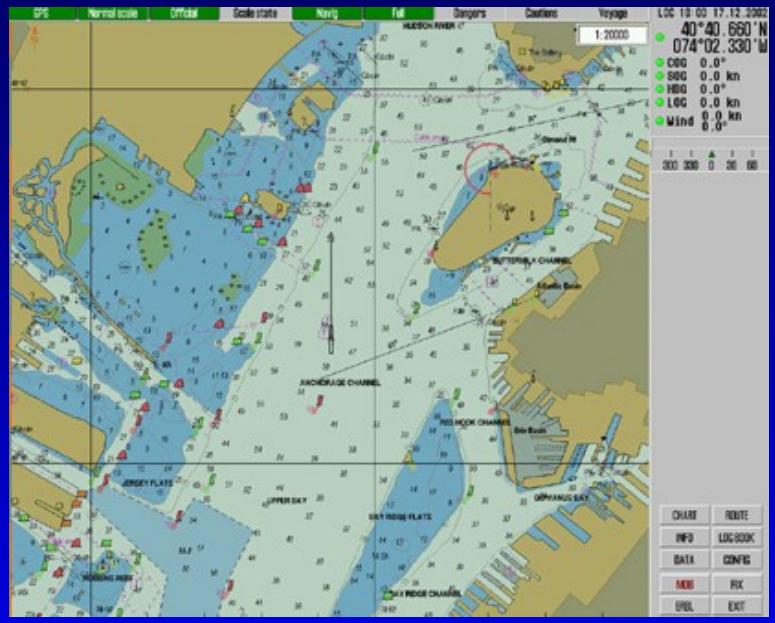
Console Displays

- Displays commands
  - Wheel
  - Throttle
- Input commands
  - RPM
  - Viewing angle and position
  - Thrusters
- Display ship info
  - Speed
  - Rate of Turn
- Wind



ECDIS & Radar

- Electronic Chart Display and Information System (ECDIS)



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Operator's Station

- Setup and monitor runs.
- Two stations, one for each simulator.

Two simulators for 2-way traffic

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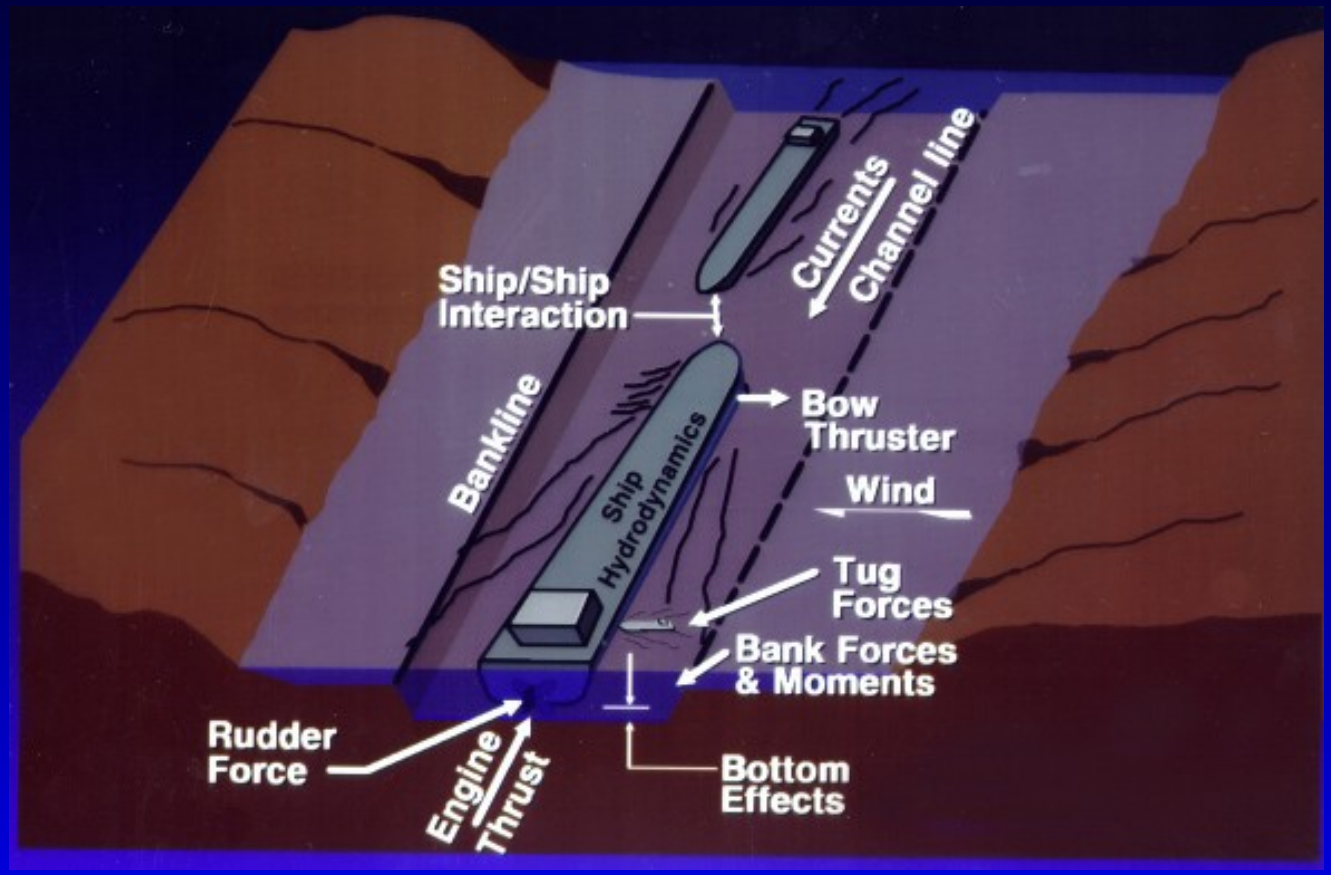
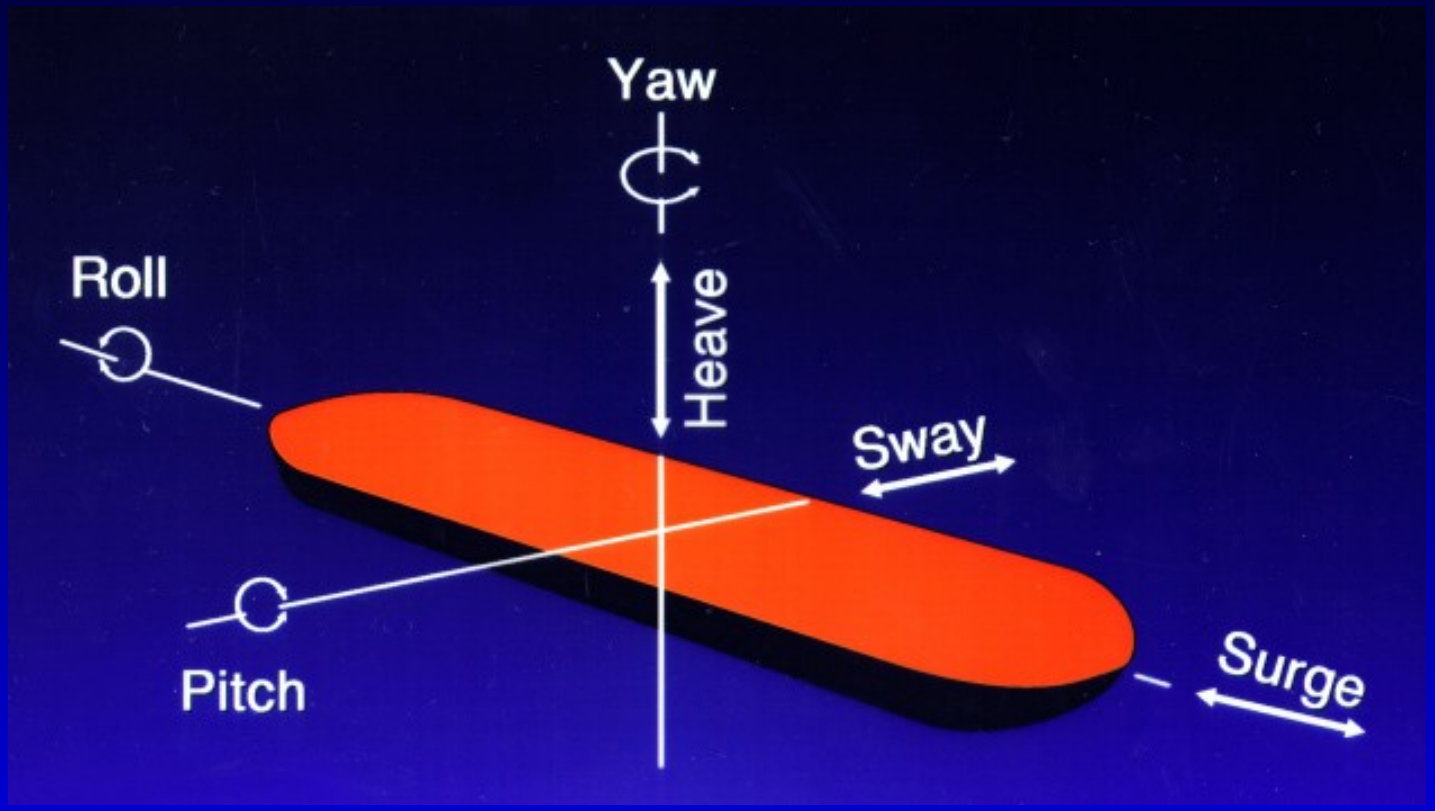
Forces Modeled



Six Degrees of Freedom



Steps for Conducting a Simulator-Based Navigation Study

- Reconnaissance Trip
- Database Preparation
- Validation
- Pretesting & Design
- Testing
- Result Analysis and Reporting

Reconnaissance Trip

- Meet with pilots
- Evaluate Port Operations
- Ride as many transits as possible
  - Clear with pilots, ship master, agent, customs
  - Severe Navigation Conditions
    - Large ships
    - Currents
    - Two-way traffi
- Video & Photos

Database Preparation

- Visual Databases
- Environmental Databases

Visual Databases

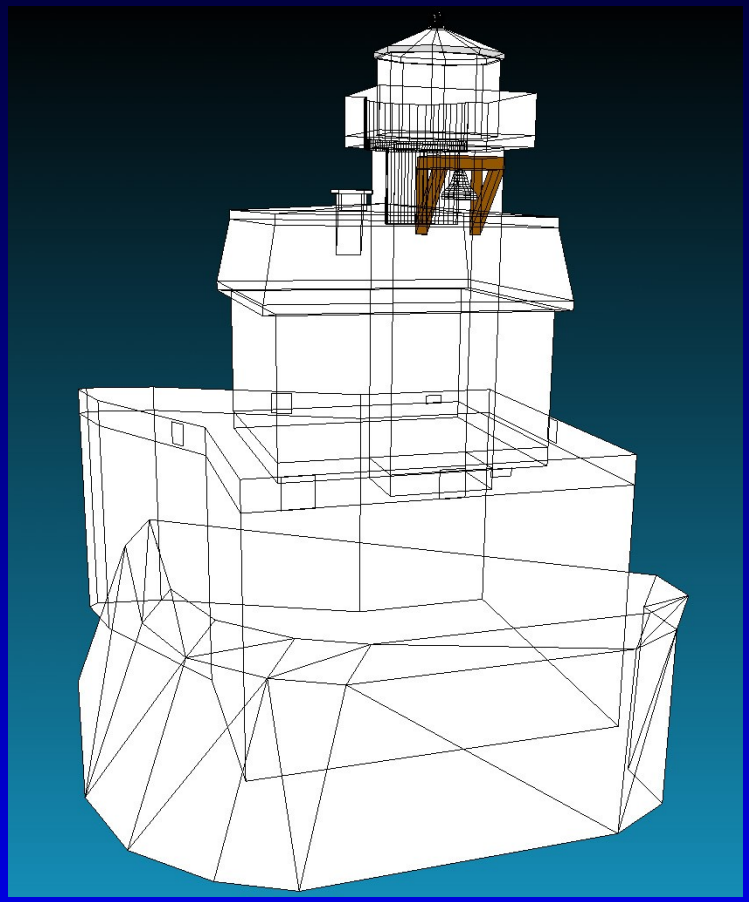
- Represent the simulated world as realistically as possible.
- Visual Scene
  - Projected in front of pilot
- Radar
  - Radar console on bridge
- Electronic Chart Display and Information System (ECDIS)
  - ECDIS console on bridge

Visual Scene

- Include basic requirements for navigation.
  - Ownship bow image.
    - Ownship is the vessel being simulated.
  - Shoreline
  - United States Coast Guard maintained Aids-to-Navigation (ATONS)
  - Informal ATONS
    - Steeples, radio towers, etc.
  - Bridges.
  - Important docks and other structures.
  - Other vessels for two-way traffic.
  - Local structures to provide feel of realism.

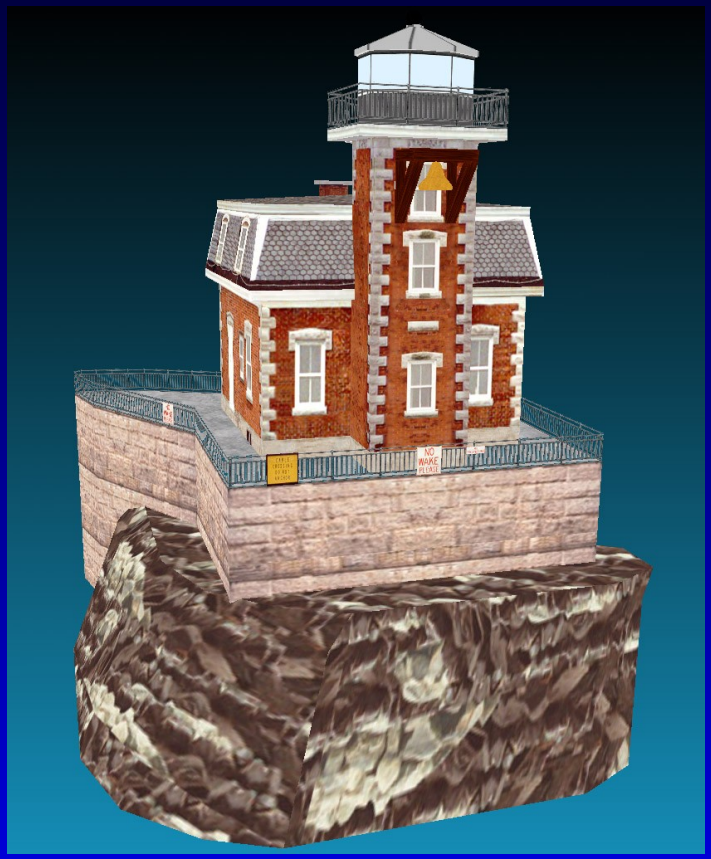
Visual Scene Development

- All objects are constructed with three- and four- side polygons.
- Wire frames are then given a texture or “skin.”



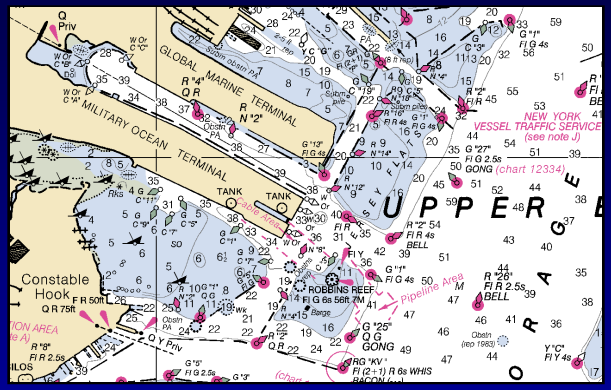
Visual Scene Development

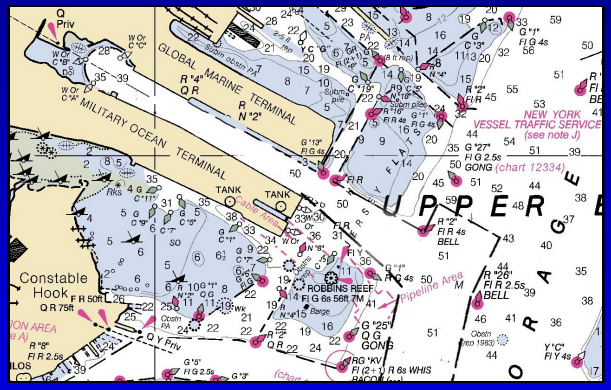
- Using digital images as a texture provides additional realism.



ECDIS

- Existing condition ECDIS is provided from simulator's library of navigation charts.
- Development of future condition ECDIS may be necessary.

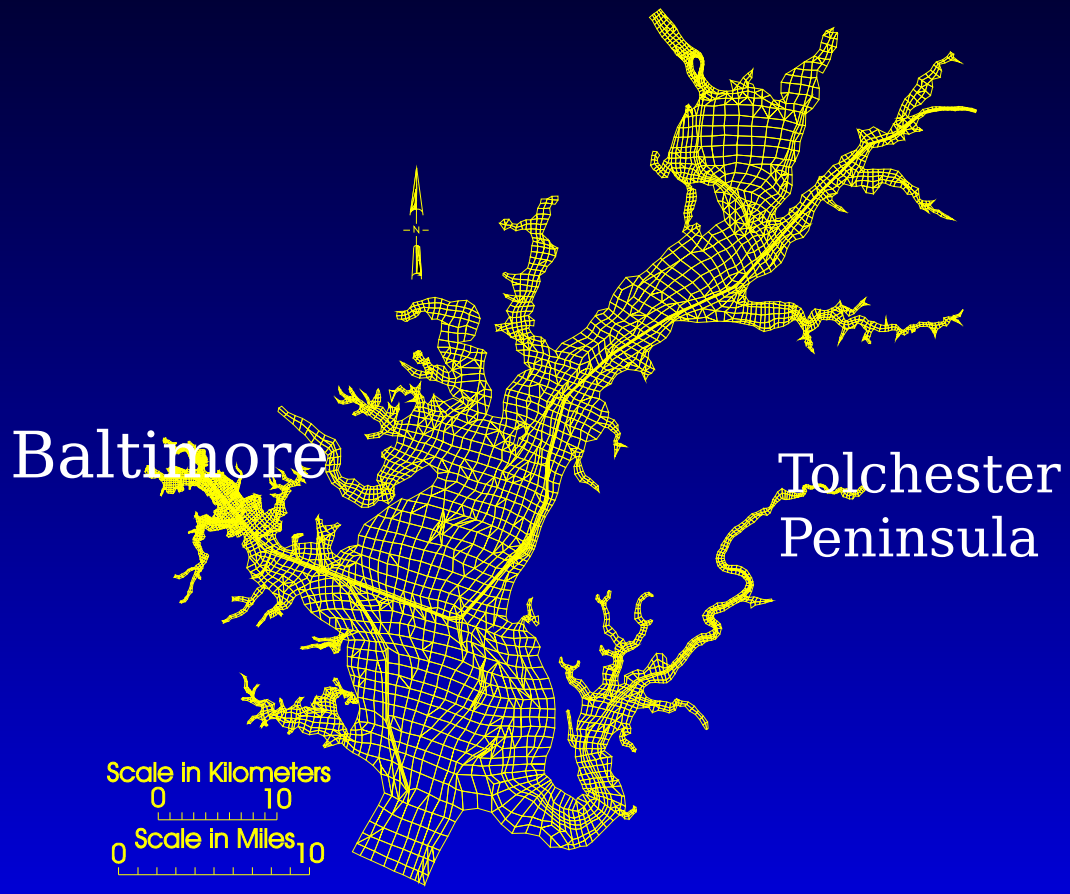




Environmental Databases

- Channel Definition.
  - Obtained from COE District Office
  - Bathymetric Surveys
- Currents
  - Usually a separate TABS-MD study
    - Can model existing and proposed conditions
  - Acoustic Doppler Current Profiler (ADCP)
    - Existing conditions only
  - Physical model
    - Can model existing and proposed conditions
- Waves
  - Usually hindcasting study determines appropriate height/period/direction to be used during simulations
- Wind
  - Wind Roses and Pilot Experience

TABS-MD Model
Brewerton / Tolchester
Navigation Study



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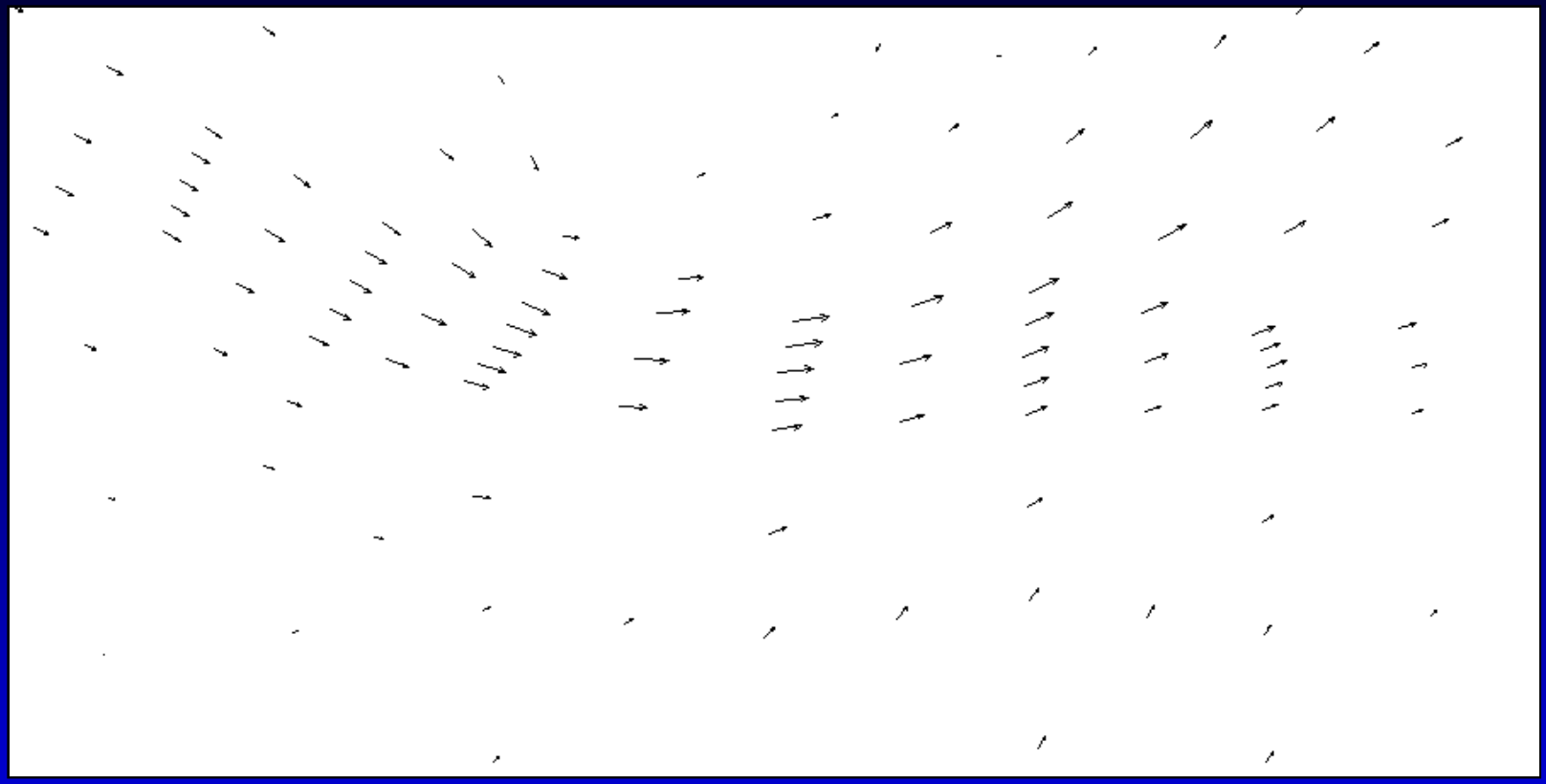
TABS-MD Model Results



Simulation Validation

- Use Experienced Pilots
- Repeat Existing Condition Simulation Runs
- Isolate Forces When Possible
  - Slack Tide
  - No Wind
- Examine & Modify Databases as Required
- DGPS Survey
  - Vessel Track Plot
  - Record rudder & engine commands

Design Mode Operation

- Assemble Design Team
  - Corps District Office - Engineers & Planners
  - Local Mariners
  - Local Port
  - U.S. Coast Guard
  - WES
- Develop Several Possible Plans
- Test Plans
- Analyze, Modify, and Retest

Testing Procedure

- Test Various Plans
  - Existing
  - Proposed (Several to Optimize)
- Test "Maximum Credible Worst Case Scenario"
- Conduct in Random Order

Savannah Harbor

Data Recorded

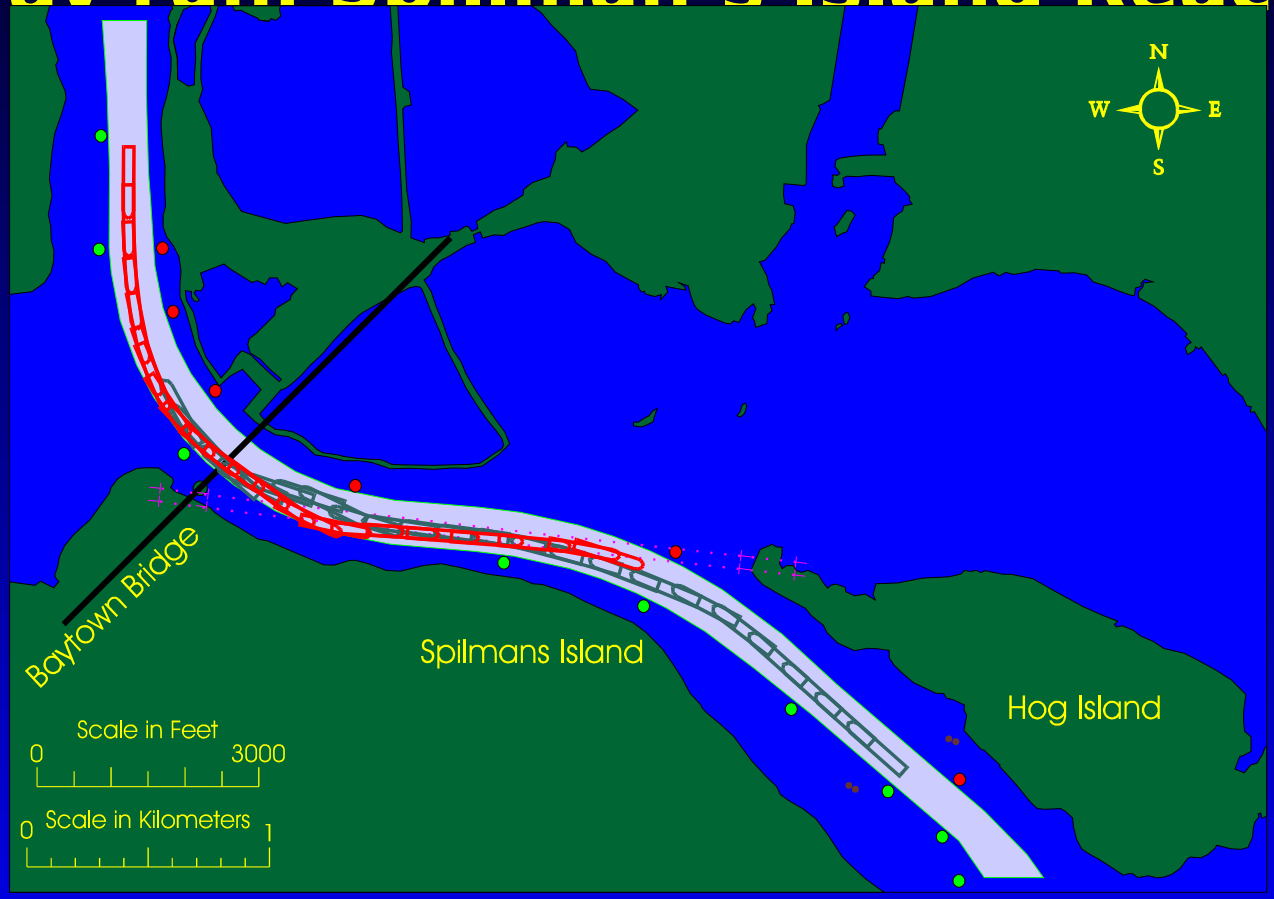
- Position
- Heading
- Rudder Angle
- Engine Speed
- Ship Speed
- Yaw Angle
- Rate of Turn
- Tug/Thruster Usage
- Port and Starboard Clearances
- Vertical Motion due to Waves (every second)

Result Analysis

- Compare Simulation Runs
  - Existing
  - Proposed
- Vessel Track Plots
- Navigation Parameter Plots
  - Rudder
  - Engine Speed
- Pilot Evaluations

Track Plot, Houston Ship Channel

2-way run, Spillman's Island Reach



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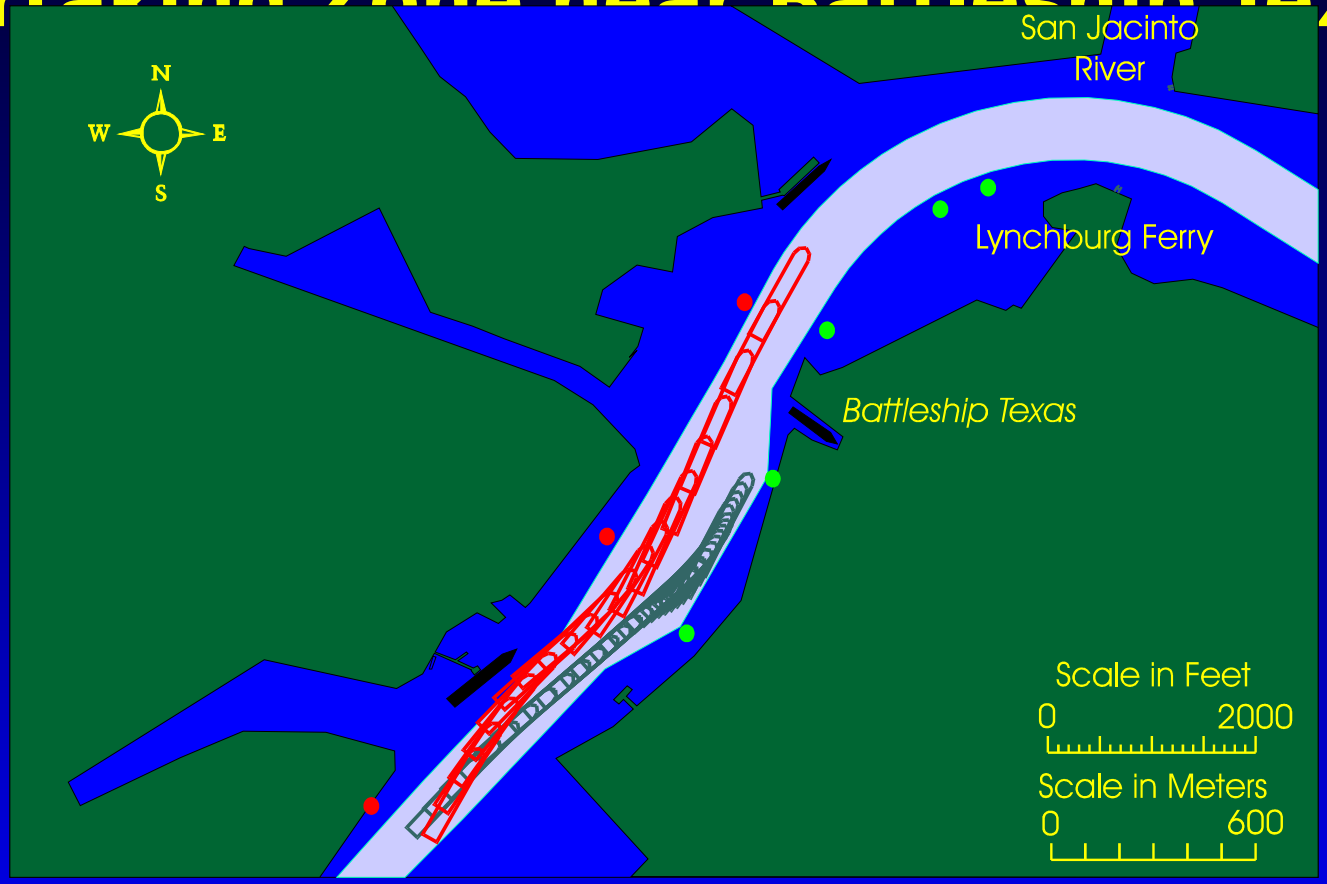
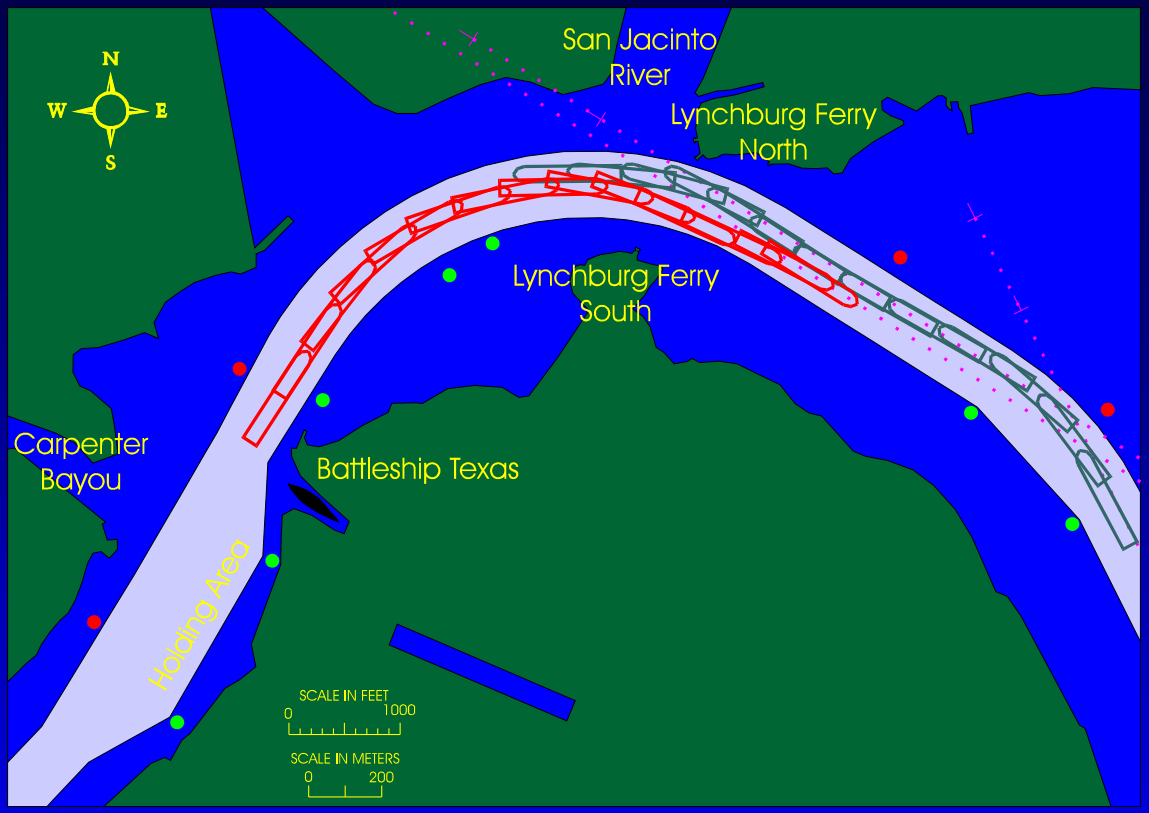
Track Plot, Houston Ship Channel

Overtaking Zone near Battleship Texas

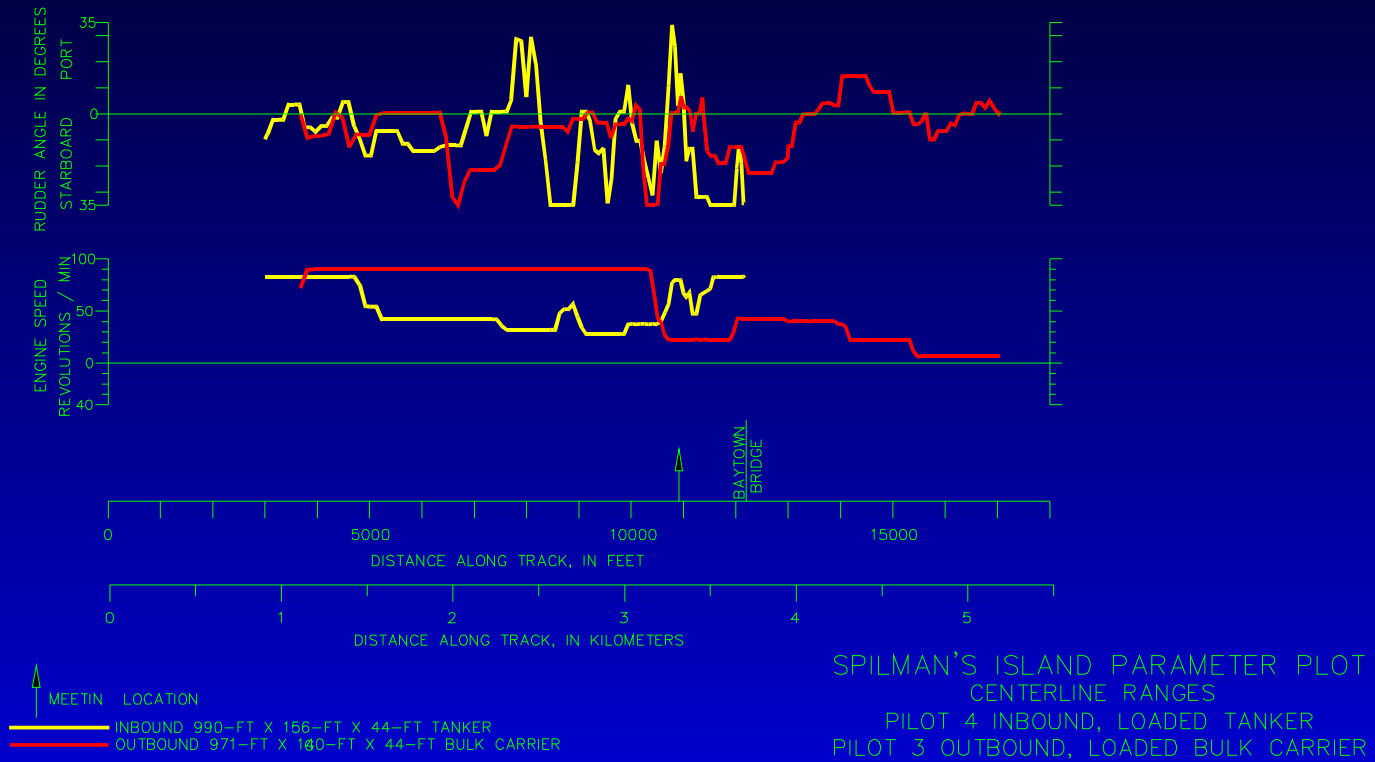


Track Plot, Houston Ship Channel

2-way run, Lynchburg turn



Parameter Plot
Houston Ship Channel



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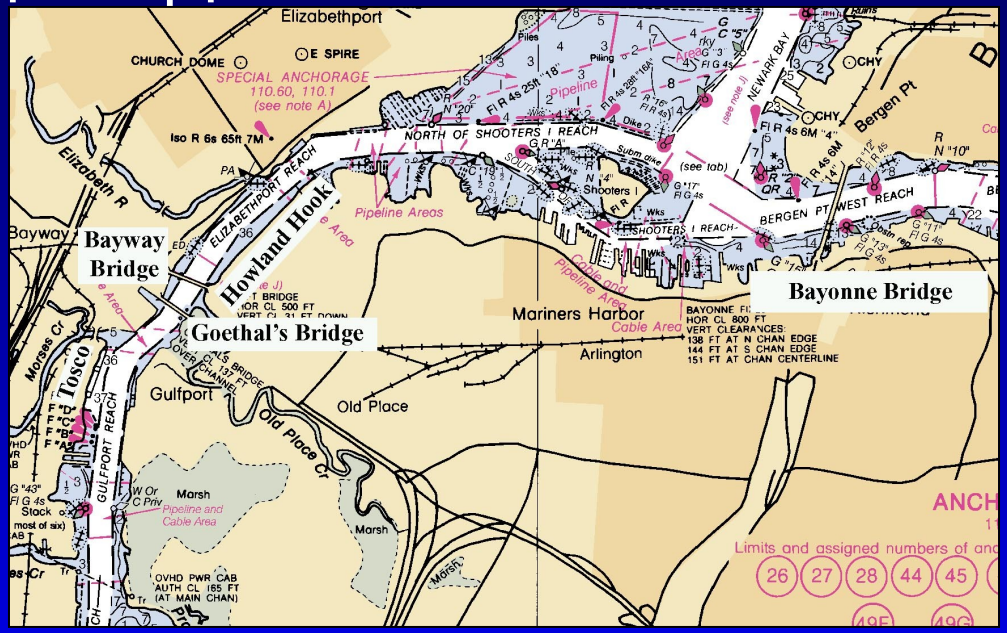
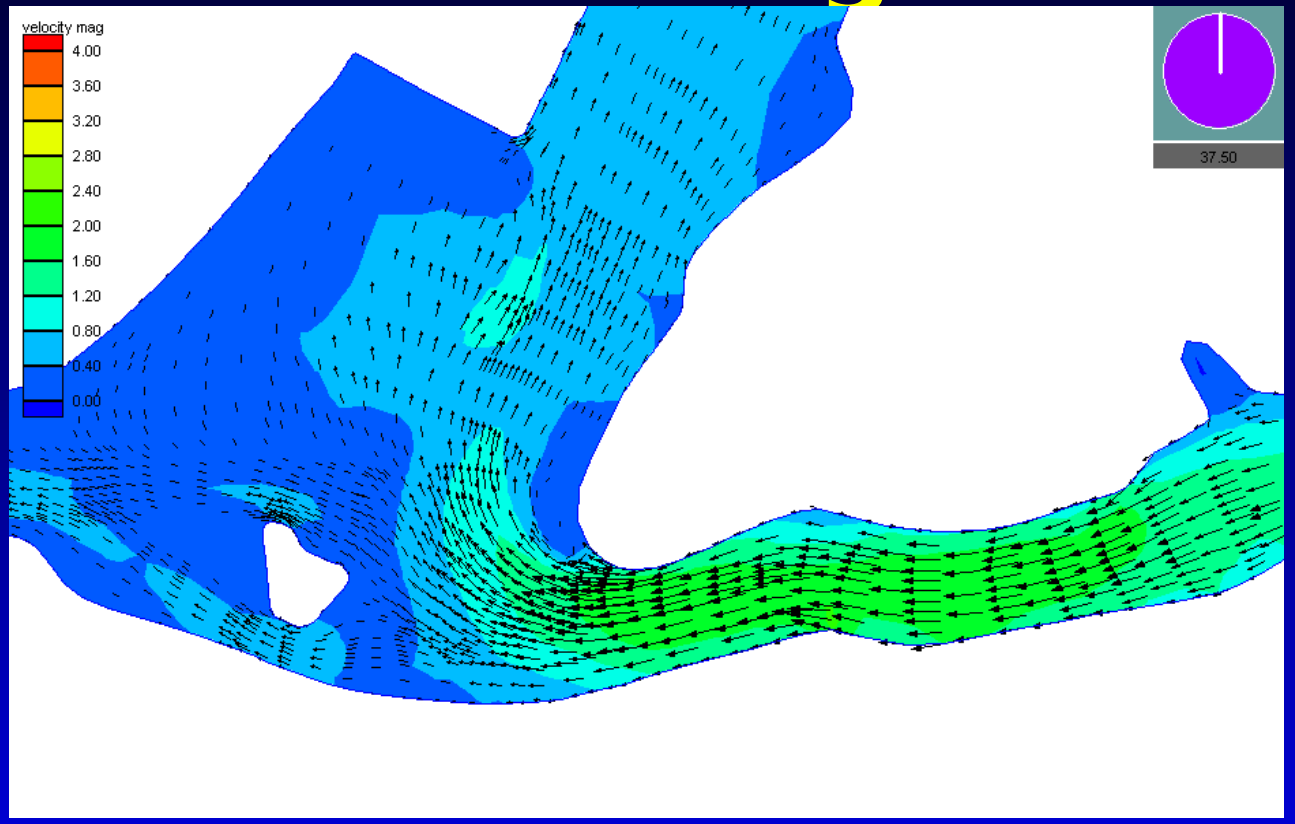
Arthur Kill Channels
NY Harbor

- Deepening from 38 to 50 ft with some channel re-alignment to accommodate S-class conta



Arthur Kill Current Modeling



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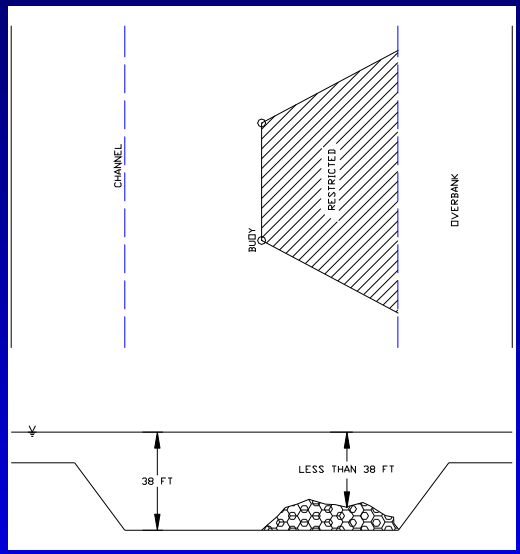
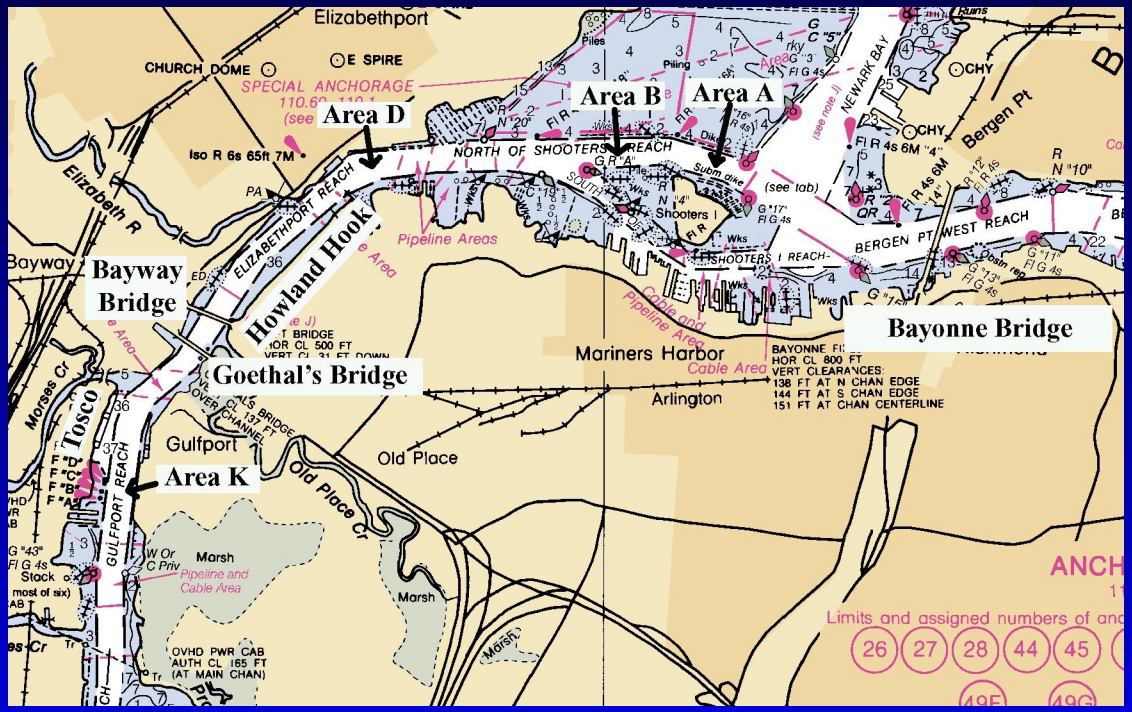
Arthur Kill Channel Dredging Contract Analysis

- Evaluate proposed areas to be buoyed off during construction of 40 ft project.



Four Dredging Locations Evaluated



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Bridge Evaluation

- Optimize span widths.
- Determine proper span location.

Conclusions

- WES Operates Corps' marine simulator.
  - Simulate ship and/or tow traffic.
  - Operates in real time.
  - Evaluates proposed changes to federal channels.
    - Existing conditions (base)
    - Proposed conditions (one or more)